The Widening Gap in Mortality by Educational Level in the Russian Federation, 1980–2001

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Objectives. We examined trends in the relation between educational level and adult mortality in the Russian Federation in the period 1989 through 2001.

Methods. We used a convenience cohort based on survey respondents' information about age, survival status, and educational level of close relatives, and applied modified indirect demographic techniques to stratify mortality rates by educational level in the study period. A random sample of 7172 respondents (response rate=61%) provided full information on 10 440 relatives.

Results. The mortality advantage of better-educated men and women in 1980 increased substantially by 2001. In 1980, life expectancy at age 20 for university-educated men was 3 years greater than for men with elementary education only, but was 11 years greater by 2001, reflecting not only declining life expectancy in less-educated men but also an improvement among better-educated men. Similar patterns were seen in women.

Conclusions. The well-documented mortality increases seen in Russia after 1990 have predominantly affected less-educated men and women, whereas the mortality of persons with university education has improved, resulting in a sharp increase in educational-level mortality differentials. (*Am J Public Health.* 2006;96: 1293–1299. doi:10.2105/AJPH.2004.056929)

The Russian Federation has experienced a major economic and health crisis since the late 1980s.[1–3] During the societal transformation that followed the fall of communism, Russian economic indicators, such as per capita income, fell sharply.[4] Life expectancy decreased dramatically between 1990 and 1994, and after a short recovery between 1995 and 1998 it has started to decline once more (Table 1).[5] The scale of the mortality changes continues to be striking; in the period 1991 through 1994, the rise in mortality was equivalent to more than 2 million additional deaths above long-term mortality rates,[6] and the corresponding number of excess deaths for the most recent 4-year period 2000 through 2003 was 3 million.[7]

The major feature in Russian mortality change was the increase in working-age mortality, especially among males, which was because of particularly large increases in deaths from cardiovascular disease and external causes.[2,3] A number of factors have been proposed to account for these enduring Russian patterns, including alcohol consumption[2,3,8] and social stress (such as massive rises in unemployment and collapse of pension schemes).[9]

In studying health trends in the whole Russian population, it is crucially important to identify groups that have been affected most by the postcommunism societal transition. Income inequalities in Russia have risen dramatically, and the current levels are close to those seen in Latin America.[4] It is therefore plausible that the social and health impact of the transition would fall unequally across different sectors of society. Indeed, using a combination of death registration data with census and microcensus data, Shkolnikov et al. found that the mortality rise in the early 1990s was steeper in men and women with lower education than in those with higher education.[10] To our knowledge, only 2 individual-level analyses on this topic have also found a divergence in mortality gradient by educational level in Russian men during the transition.[11,12] However, there is an overlap in the populations studied in the 2 reports, neither report was nationally representative, both excluded women, and they do not cover the period after 1998, when mortality increased sharply.

We used an indirect demographic technique to reconstruct the mortality experience of men and women by educational level for the Russian population in the period 1980 through 2001, thus covering the main period of the crisis (which still continues), so that we may gain some insight of how it has affected different groups.

METHODS

We had previously developed a quick, cheap, effective approach to assess levels and predictors of mortality in a population.[13,14] Our approach borrowed from demographers' indirect estimation methodology, a number of which use survey or census data to estimate mortality in countries without vital statistics. These so-called Brass techniques[15,16] are used where conventional data are unavailable, and employ simple information on the number of close kin (such as spouses and parents) and the number of them that have died to estimate mortality. We modified this method for literate and numerate populations, and showed that the method, based on data from spouses and siblings (which we extend to parents here), is a useful tool for studying mortality and its individual-level determinants in Russia.[13,14]

Subjects

We conducted a cross-sectional survey of national samples of the Russian population in 3 waves in July, September, and November 2002. The data were collected in collaboration with the Russian Centre for Public Opinion Research and the New Russia Barometer survey program.[17] The population sample was selected in a multistage process. Russia was first stratified into 22 regions, and each region was further stratified into urban and rural areas. Within this framework, towns and settlements were randomly selected proportionately

TABLE 1—Official Estimates of Life Expectancy at Birth in Years for Russian Men and Women, 2001–2003

Year of Birth	Men	Women
1980	61.44	74.03
1981	61.69	73.30
1982	62.36	73.81
1983	62.26	73.58
1984	61.72	73.03
1985	62.75	73.32
1986	64.88	74.37
1987	64.93	74.39
1988	64.66	74.32
1989	64.23	74.59
1990	63.79	74.42
1991	63.44	74.31
1992	62.02	73.77
1993	58.91	71.88
1994	57.62	71.18
1995	58.30	71.71
1996	59.77	72.52
1997	61.02	72.96
1998	61.39	73.27
1999	59.98	72.49
2000	59.15	72.36
2001	59.08	72.28
2002	58.88	72.03
2003	58.68	71.89

to population size. Primary sampling units were randomly drawn from these locations. In each primary sampling unit, an address was randomly selected, and interviewers were instructed to seek a face-to-face interview at every *n*th eligible household. At each address, the interviewer asked for a respondent matching an age–gender–education grid. If more than 1 respondent was eligible, the person with the most recent birthday was selected.

In total, we identified 11 776 eligible respondents. Of these, 3837 declined to be interviewed, and 608 were unable to answer because of bad health or other reasons. In addition, 159 interviews were interrupted or rejected during control. This yielded an overall response rate of 61%. The 7172 participating respondents were asked to provide information about their parents, eldest 2 siblings, and first husbands, a total of 26 709 relatives. We did not collect information on wives because our pilot study suggested that husbands underestimate their wives' mortality, consistent with the general experience that men are rather poor at reporting such events.[18–20]

Measurements

Information collected about each relative included year of birth, whether they were alive or dead, and, if applicable, year of (or age at) death. Further details including cause of death and other details of relatives' lifestyle were sought for parents (except for those who died before 1972), siblings aged 20 years and older, and first husbands; certain exclusions were made on the basis of cost and the low likelihood of gathering accurate data. These additional data included smoking status (all relatives), alcohol consumption (all relatives except mothers), frequency of contact with respondent (siblings only), marital status (siblings only), and education level (siblings and husbands only). Respondents also answered questions concerning their own age, gender, socioeconomic characteristics, social and political attitudes, childhood circumstances (such as lack of food and family size), and educational level.

Education information on these 6737 male and 3703 female relatives was categorized into 3 groups: elementary (including incomplete secondary), intermediate (secondary, including specialized vocational and technical education), and university (higher, including incomplete higher). Educational information was not collected on parents, but they are included in the mortality estimates for the total population.

For persons with information on education, we constructed matrices of deaths and exposure for each educational level in person-years, separately for men and women in each single calendar year and year of age between 1970 and 2001 (a total of 197 000 person-years with information on educational level from 1980; Table 2).

Statistical Analyses

Our main interest was in temporal changes of mortality from 1980. We therefore constructed period life tables (rather than cohort ones) using education level–specific mortality rates for males and females. We present here age-standardized summary indices of mortality: expectation of life at birth (e_0; the most widely used index and therefore available for comparison with data from different sources) and, since our main interest is in differential adult mortality, expectation of life at age 20 (e_{20}) and the probability of surviving from age 20 to 65 years ($_{45}p_{20}$). Tables with all estimates are available on request.

Although we have information on 1735 deaths by educational level, by the time the sample is broken down into 2 genders by 3 educational groups and by a number of time periods, the numbers are too small for useful analysis of trends with conventional separate life tables. Moreover, computing life tables for broad periods, such as comparing the 1980s with the 1990s, gives very little information on shorter-term trends. We therefore fitted a series of generalized additive models[21] to the mortality data for each gender by education

TABLE 2—Distribution of Russian Sample by Educational Level: Russia, 1980–2001

	Men			Women		
	No.	Exposure by Educational Level, Person-Years	Deaths	No.	Exposure by Educational Level, Person-Years	Deaths
Persons with data on education	6737	120 532	1365	3703	76 779	370
Elementary	1337	23 435	492	796	15 498	184
Intermediate	4034	72 341	679	2097	43 979	151
University	1366	24 756	194	810	17 302	35
Persons without data on education	4300	72 253	1778	5825	104 623	1916
Total	11 037	192 785	3143	9528	181 402	2286

group and for the whole population, including those for whom no educational information was available.

The model is:

$$\text{(1)} \qquad \text{logit}\,(m_{at}) = s(a) + s(t) + e_{at},$$

where m_{at} is the mortality rate at age a in year t, s(a) and s(t) are smooth nonparametric curves with no prespecified form so that the data can "speak for themselves," and e_{at} is a random error term.

The model is based on an iterative scatterplot-smoothing algorithm, which obtains a preliminary smoothed value and uses this value to fit the model to obtain a better value, until the model converges to a smooth value with optimal statistical properties, taking into account that the process is based on a generalized linear model (binomial), rather than a standard linear model. Therefore, the model is an extension of a standard generalized linear model, but with the added flexibility of not prespecifying the form of the dependence with age or time; it has been used in a number of different areas in epidemiology.[22–25]

We do not include interaction terms, because we fit models separately to each gender and educational level group. The method does not estimate annual values, only smoothed trends, because annual numbers of deaths are small. We used a particular widely used smoothing procedure, the LOWESS smoothing algorithm (R Development Core Team, c/o Institut für Statistik und Wahrscheinlichkeitstheorie, Technische Universität, Wien Wiedner Hauptstraße 8-10/1071, 1040, Vienna, Austria), which produced a value for the official data that was comparable to the degree of smoothing we used in our model.

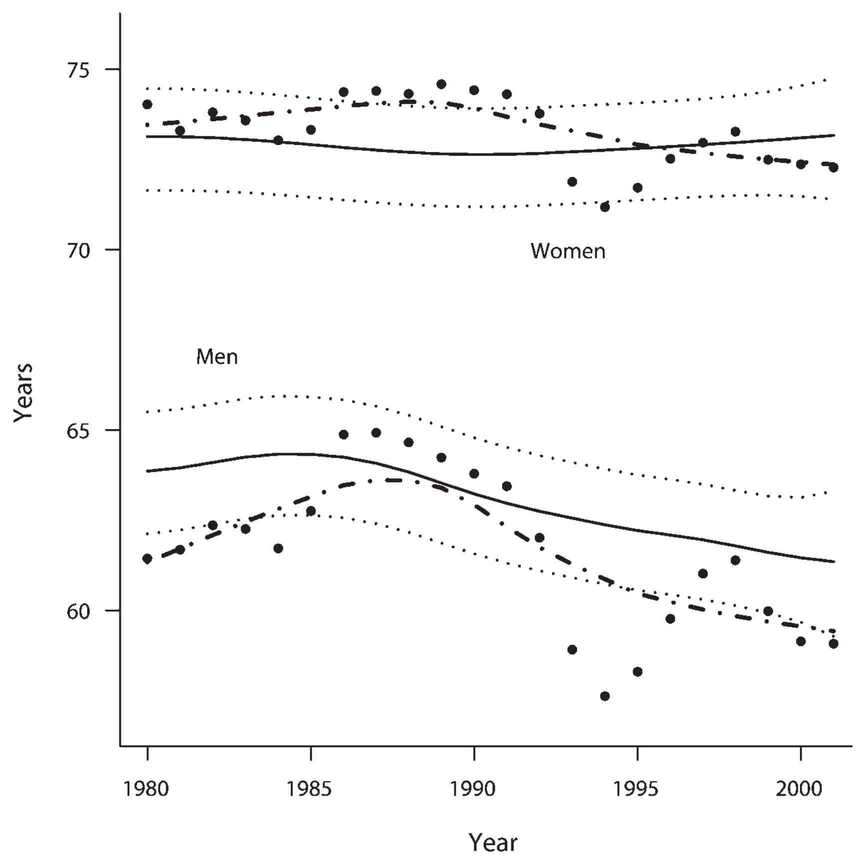
We present results only from 1980, although we fit the models from 1970 in order to improve the precision of the estimates from 1980. Estimates of overall life expectancy at birth are based on models fitted to all ages, and education level–specific estimates use data only on those aged 20 and over. We calculated approximate 95% confidence intervals (CIs) for the probability of surviving from age 20 to 65 using Greenwood's formula.[26]

RESULTS

Validation of Estimates

Our main purpose was to investigate the differential experience of educational level groups over the period, but we first examined whether the overall values that we obtained were acceptably close to the official values for the whole population. To do so, we used the fitted mortality values to construct period life tables for men and women in each year from 1980 to 2001, and derived the values of life expectancy at birth and the probability of surviving from age 20 to 65. As expected, the logit of mortality rates increased steadily, in a largely linear fashion, with adult age in each case (not shown). The agreement in life expectancy at birth of the estimated and official values was good; our estimate for the period 1980 through 2001 for e_0 was 67.8 years, compared with the official value of 67.3 for both genders combined; the male value was 1.4 years above and the female 0.3 years below the official values. Our estimates of the probability of survival of men between ages 20 and 65 fell from 0.58 in the period 1980–1984 to 0.52 in 1997 through 2001 (official values fell from 0.54 to 0.48), whereas the values for women were relatively constant in both cases at around 0.80. On this basis we concluded that these data produced estimates of acceptable quality for analytic purposes.

Figure 1 shows the smoothed estimated values for period life expectancy at birth for the years 1980 through 2001, with their approximate 95% CIs, together with the corresponding official values for the same period. Because our estimates are smoothed, we also present a smoothed trend of the official life



Note. The figure shows official values (circles), the smoothed official trend (dashed line), and the trend estimated from our data (solid line), with values calculated from 95% confidence intervals of estimated mortality rates (dotted lines).

FIGURE 1—Life expectancy at birth among Russian men and women, 1980–2001.

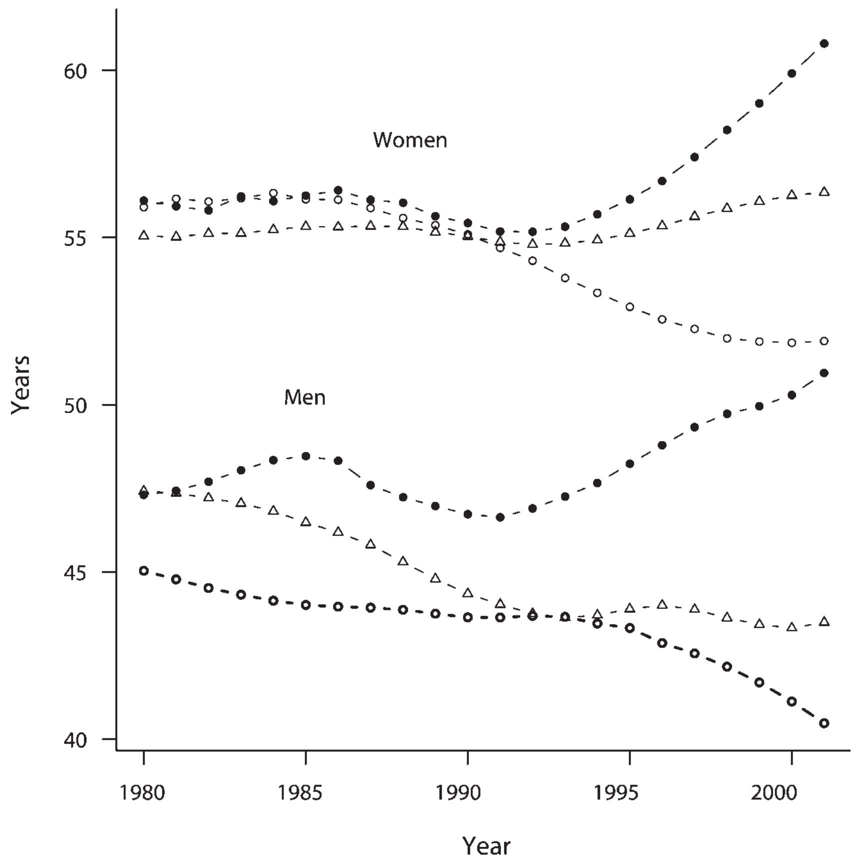
expectancy at birth values for more direct comparison. Our e_0 trend estimates were based on relatively small numbers of events; among those aged 20 to 65 there were, on average, 90 male deaths and 30 female deaths per annum in this period. With such small numbers, the annual estimates were inevitably imprecise. Nevertheless, for males, where the numbers were larger and the trends more pronounced, we were able to detect the main trend. For females, with few events annually, the data did not identify a major trend, but the smoothed line was well within the statistical error bounds. The estimated probability of surviving from age 20 to 65 (not shown) exhibited a trend very similar to life expectancy at birth, as would be expected, since changes in life expectancy at birth over the period were largely determined by changes in working-age mortality.

Trends in Educational Differentials

For each educational level, we used the fitted rates to construct period life tables for each year. Because our interest is in adult mortality, mortality trends are different at adult and below-adult ages, and we do not have useful estimates of exposure by educational level at young ages (addressed in more detail in the Discussion), we show life expectancy at age 20 and the probability of surviving from age 20 to 65 (Figures 2–4).

Those with primary and intermediate education showed increasing mortality and decreasing life expectancy over the period 1980 through 2001. In contrast, the mortality of better-educated men declined in the late 1980s, but this was more than offset by improvement over the 1990s. Changes in the levels of women's mortality overall were smaller than in men's over the period, but the patterns and differentials were very similar. In 1980 men with the lowest level of education had a 3-year-lower expectation of life at age 20 than those in the highest-education group; by 2001, this difference had increased to 11 years. For women, life expectancy at age 20 in those with elementary education declined by 4 years between 1980 and 2001, but it increased by 5 years in women with higher education.

Finally, given the results described above, we investigated whether there is any suggestion in our data of a differential social impact of the societal transformation by educational level. The survey collected information on respondents' perceptions of their conditions now and before the collapse of the USSR on a 10-point scale. Older respondents were the most likely to have perceived their conditions as having deteriorated by 2 or more points after 1989 (we could collect such information only from respondents; Table 3). Education-associated differentials in perception of conditions have distinctly widened for younger groups. For example, only 1 in 5 men under age 40 with university-level qualifications believed that their position had deteriorated, compared with 35% of men under 40 with elementary-level education. Although we need to be cautious in interpreting these patterns as referring to cohorts, the widening gap in mortality nevertheless appears to be moving in parallel with a widening perception of worsening conditions by educational level.

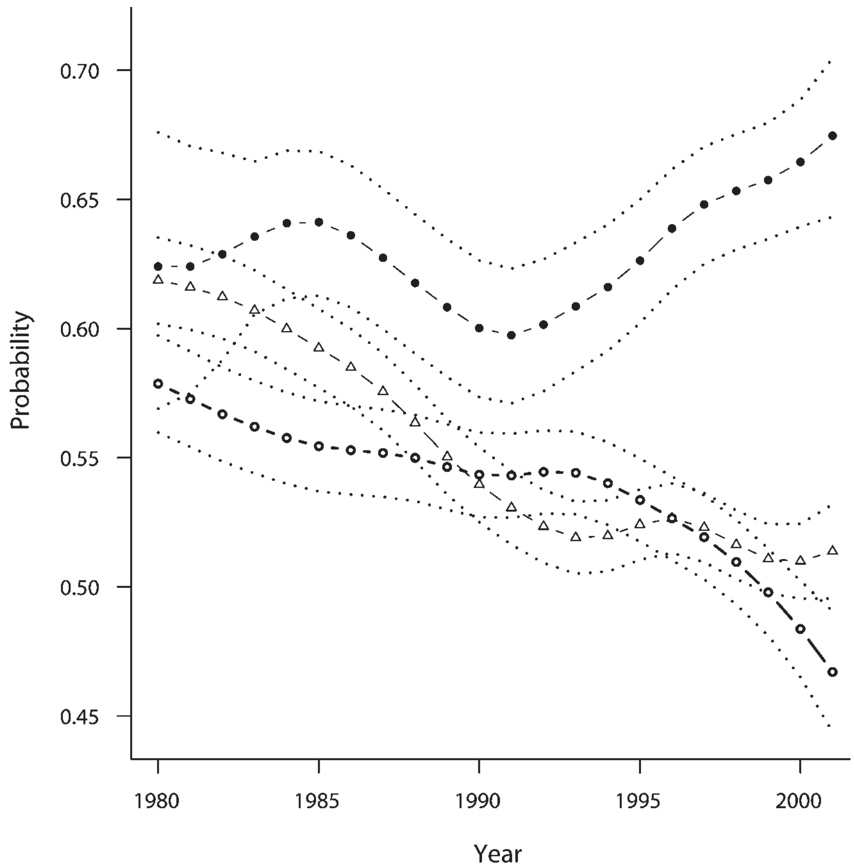


Note. The figure shows values for educational levels: elementary (open circles), intermediate (triangles), and university (filled circles).

FIGURE 2—Smoothed trends in life expectancy at age 20 by educational level among Russian men and women.

DISCUSSION

We have shown that the use of a simple and cheap indirect technique can provide data of acceptable quality, and that statistical models such as generalized additive models can recover the levels and main trends in mortality, and provide information on differentials by educational level. In considering differences by educational level, especially in the 1990s, the mortality of the least-educated has deteriorated, whereas that of the best-educated has improved, with intermediate groups showing an intermediate pattern. Thus, inequalities in mortality—and by



Note. The figure shows values for educational levels: elementary (open circles), intermediate (triangles), and university (filled circles), together with 95% confidence intervals (dotted lines).

FIGURE 3—Smoothed trends in the probability of surviving between age 20 and 65 by education in Russian men.

implication, in other aspects of health—have increased over the period 1980 through 2001, and this pattern appears to have accelerated in the most recent period.

Two smaller pilot studies have previously shown that the indirect technique we used is sufficiently sensitive to study mortality levels and their determinants.[13,14] When evaluating these pilot studies, we discussed a number of potential biases in such approaches, and we concluded that they are not of sufficient magnitude to seriously affect the results. Some of these methodological issues are summarized below.

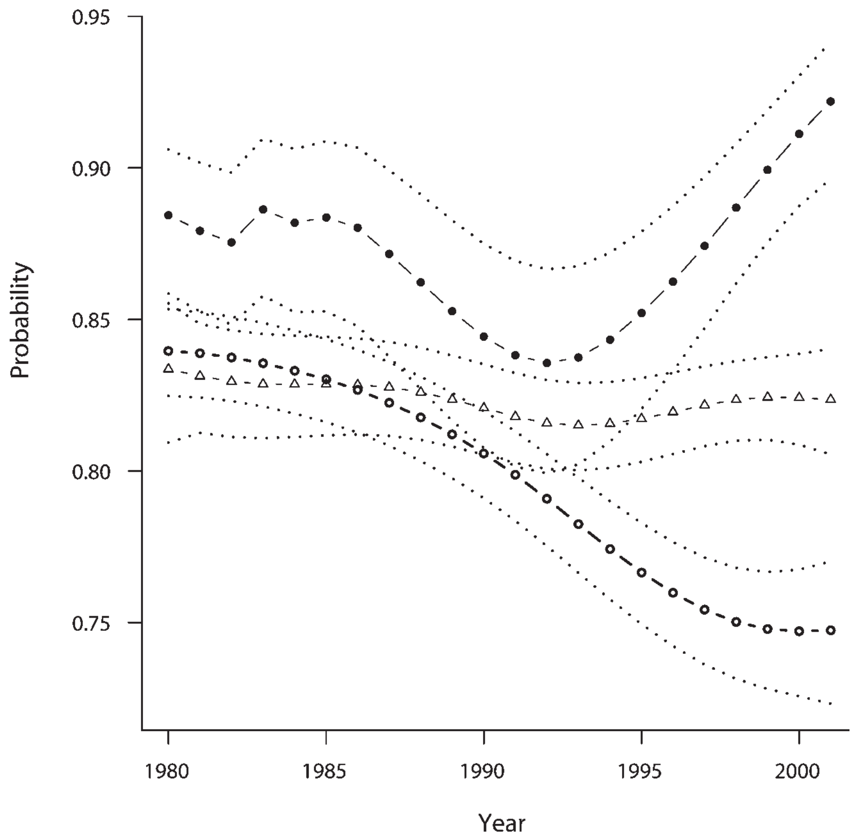
First, the sample may not be precisely representative for the overall Russian population in that, for example, it overrepresents married people and those from large sibships (i.e., persons sharing both parents). We have investigated such possibilities and found that the effect is trivial. There is no real effect of sibship size on mortality, and the proportion of never-married persons is too small (under 1% of men aged 55 to 59 in the 1979 census) to suggest a potential for bias.[27] Moreover, control for marital status did not change our results.

The second set of issues relates to the potentially differential inclusion of individuals associated with clustering of mortality within families—those from high-mortality families would be less likely to be alive and hence to report on their relatives. However, this does not lead to problems in interpretation of this study. A simple example is of a population consisting of pairs of siblings of similar age and with equal probability of survival p. At the end of the period, a proportion $p \times p$ of the pairs of the original population have both sibs alive; $2 \times p \times (1-p)$ has 1 alive and 1 dead; and $(1-p) \times (1-p)$ has both dead. Ignoring random variability, with 1000 sibling pairs originally, there would be $2000 \times p$ persons alive and interviewed, $2000 \times p \times p$ with a living sibling, and $2000 \times p \times (1-p)$ with a dead sibling (cases with both siblings dead will not be recorded). The proportion reporting a dead sibling is $2000 \times p \times (1-p)/(2000 \times p)$, or exactly $1-p$; that is, it is unbiased, because the estimated mortality is equal to the true population values (further details on this issue are available on request). The relative risks for comparing subgroups was therefore unbiased.[28]

A third potential bias is specifically related to education. Educational level recorded was that at the time of death for decedents, or at interview for survivors. Thus, for example, a person with university-level education is assumed to have had that level for all earlier ages as well, which will lead to some minor bias in estimated life expectancy as some educational exposure will be incorrectly recorded in our data, especially in childhood. However, because we confine all analyses of educational differentials to those aged 20 and over, the contribution of childhood mortality cannot bias our estimates.

Fourth, a linked issue is potential selection bias, if large numbers of healthier adults were to leave the elementary-education group and move to higher educational groups. However, official census data confirm that rates of migration to higher educational levels by adults in all birth cohorts included in our analysis was very low.[10] We also found that our results were similar with analysis confined to ages 30 and above, where few people change their educational level. We therefore concluded that our results were not affected by such selection bias.

Fifth, because data were collected retrospectively for both mortality and education, reporting bias needs to be considered. If respondents were more likely to report lower educational achievement for a relative who had died, this would create artifactual differentials in mortality by educational level. However, the distribution of reported educational



Note. The figure shows values for educational levels: elementary (open circles), intermediate (triangles), and university (filled circles), together with 95% confidence intervals (dotted lines).

FIGURE 4—Smoothed trends in the probability of surviving between age 20 and 65 by education in Russian women.

TABLE 3—Proportion of Men and Women Who Reported Present Conditions Substantially Worse than Before the End of Communism, by Age and Educational Level

	Men			Women		
Age Group, y	Elementary, %	Intermediate, %	University, %	Elementary, %	Intermediate, %	University, %
<40	34.7 (147)	29.5 (1123)	21.1 (269)	41.0 (130)	33.4 (1105)	27.5 (1105)
40–59	58.9 (168)	44.5 (745)	43.1 (191)	42.2 (128)	47.0 (803)	39.5 (239)
≥60	57.4 (361)	53.2 (166)	47.8 (82)	54.5 (709)	55.4 (339)	63.7 (118)

Note. Weighted sample size in parentheses

achievement in relatives is in agreement with other surveys,[29] and there is no obvious reason why such a bias in reporting should increase for more recent deaths. Indeed, it might be expected that education reporting was more accurate for relatives who died more recently. Reporting bias is therefore unlikely to have contributed to the observed divergence of mortality trends by educational group.

Finally, a major limitation of this study is the relatively low statistical power. Although we had data on 1700 deaths and 200 000 person-years, the specific groups for gender, educational level, and calendar year were too small for precise estimates (for example, there were on average fewer than 20 female deaths with educational information per annum). We tried to minimize this problem by generalized additive modeling, but there are limits to statistical models. Given the larger numbers of events, we are more confident with the results on men. Nevertheless, it is reassuring that the results on levels and trend data on educational differentials were similar and consistent with other data from Russia[10,11,30] and Estonia (an ex–Soviet country).[31]

It is becoming clear that the social impact of transition has not been equal in Russia. In addition to regional differences,[32,33] persons with low education, of elderly age, and living in vulnerable sectors of the economy (e.g., heavy industry) have been hit hardest.[34,35] The individual-based analyses show that the rise in mortality follows a similar pattern. Consistent with results of the early analyses of routine data in Russia[10] and Estonia,[31] and with findings in the St. Petersburg cohort,[11,12] we found that the crisis has had a disproportionate impact on the more disadvantaged sectors of Russian society. Regional analyses also showed that the rise in mortality was more pronounced in areas characterized by high levels of social stress.[9,36] Unfortunately, we cannot establish whether this was because of education per se or to other socioeconomic factors associated with education, such as income or social class.

Over time, the educational level of the population has increased. Between 1980 and 2000, the proportion of our subjects aged 20 and older with only elementary education decreased from 38% to 17%, whereas the proportion of university-educated persons increased from 16% to 23%. Despite this strong secular trend, seen both here and elsewhere,[10] this most vulnerable group forms between more than one third and one sixth of the population over the study period. Irrespective of whether the proportion of persons with low education increased or decreased, the fate of these people was a crucial component of overall population health in the transition period.

We have focused on identifying the main trends of mortality by educational level, rather than explaining the trends. The explanations put forward most often include material deprivation, psychosocial stress, and health behaviors, particularly alcohol consumption. Unfortunately, we do not have data on the first 2 factors, and we are cautious about drinking and smoking reported by relatives. It is likely that the reasons for the diverging educational trends are complex, as are the mechanisms linking socioeconomic position with health. Whatever the proximal causes, however, the speed of the increase in social inequalities in health in Russia since the 1980s is unparalleled in Western countries, and it constitutes another unintentional consequence of the post-communism societal transformation. ■

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Contributors

M. Murphy contributed to the study concept and design, analysis and interpretation of the data, and writing of the article, and provided statistical expertise. M. Bobak contributed to the study concept and design, acquisition of the data, analysis and interpretation of the data, and writing of the article; he also obtained funding. A. Nicholson contributed to analysis and interpretation of the data, and writing of the article. R. Rose contributed to the study concept and design, acquisition of the data, and writing of the article, and provided technical and administrative support. M. Marmot contributed to the study concept and design, and writing of the article; he also obtained funding.

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Human Participant Protection

No protocol approval was needed for this study.

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